**EXHIBIT 14**

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**TRANSONIC PRO AND YARDGARD SONIC/ULTRASONIC UNITS**

**REDUCE MOUSE DAMAGE IN HOME AND GARDEN.**

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## ABSTRACT

Mice in homes contaminate food with droppings and urine. They are vectors for Hanta virus and Lyme's disease. Ultrasound generating devices offer a relatively untested means to reduce mouse problems. Ultrasound units tested included 1 TRANSONIC PRO, (Frequency 3 – 40 KHz at a sound pressure of 96 db @ .5 m) and one YARDGARD unit (freq. 15 kHz-25 kHz, 90 dB at 1 m) both from Bird-X Inc. of Chicago). Efficacy was assessed using indirect evidence of ultrasound detection/avoidance by mice based on absence of mice trapped or droppings. Tests compared three years mouse trapping/dropping count data from my farm house, Marquette County, Wisconsin. Tests used one TRANSONIC PRO in the back hall/entry, dates 2 Aug – 5 December in both 2009 and 2010; with the ultrasound unit set to "on" in 2009 and to "off" in 2010. A repeat test was done with the sound unit on continuously 25 November 2012 to 25 November 2013, using the medium volume mouse setting, snap traps and counting mouse droppings in the kitchen area. The YARDGARD unit was used 9/2 - 9/28/09 for comparison with records of nightly tomato loss for 8/10-9/1/09. No mice were trapped or droppings observed for 4 months in 2009 versus 32 mice trapped in the house and 67 droppings collected on the counter in 2010- an average of 8 mice trapped and 16.75 droppings found per month. In the 12 month test 2012-2013 with the sound unit on, six mice were trapped and only 3 droppings found on the counter on a single occasion- an average of .5 mice trapped/month, and 0.25 droppings/month observed. Substituting a 1 for the zero mice trapped and zero droppings found, Chi Square test $X^2$ values for mice in 2010 is 961 ($p = .000$) and the $X^2$ value for mouse droppings in 2010 is 4356 ($p = .000$). Chi square values for mice/month and droppings/month for 2012/13 test versus 2010 data were 11.343, ($P = 0.0034$) and 26.855, ($p= 0.000001$), respectively. No differences other than the use of the ultrasound units were present between these tests. No tomatoes were damaged in 21 days the YARDGARD was "on," in the garden, versus 6-8 tomatoes damaged/night before the unit was introduced. Clearly, mice perceived the sounds generated and responded by almost complete avoidance of the areas of sound use. Efficacy of the unit was 100 % for the areas tested in 2009, and a 93.75% reduction in mice trapped per month for the 2012/2013 full year test cycle. Areas evidencing reduced mouse presence with sound units on versus units off included the basement stairs and hallway, kitchen and basement, or roughly 440 sq feet (roughly 42 sq meters) on two levels. The combination of the Transonic Pro sounds units and set mouse traps successfully worked to eliminate virtually all mice from the homes' living quarters and eliminated need for constant cleaning of kitchen counters and floors. Traps appeared to catch the few mice that did not respond to the sound alone, and the great reduction in mice trapped with the unit in use made clear that a high proportion of the mice were repelled by the sound the TRANSONIC PRO broadcast and avoided the area where baited traps existed as a result.


## INTRODUCTION

Mice damage homes by gnawing on wiring or baseboards, nesting in drawers and closets, and contaminating food supplies. They leave a noisome mixture of abundant droppings mixed with strongly scented urine, especially in their nests. Mice are known vectors for human sicknesses such as Hanta Virus and Lyme's disease. At the least, mice in a house are a nuisance, gnawing the soap, drowning in the toilet, and leaving droppings on counters, table tops, on silverware, in cupboards, drawers, and on floors. In old homes, and restaurants it requires continual effort to clean up after the little varmints. As a result, most humans are happy to trap mice or poison them. People have been searching for the perfect

mousetrap for centuries, but most would prefer not to have to empty those traps, nor to worry about poisons potentially being eaten by pets or children. They want a simple means to keep mice out of their homes. Sonic and ultrasonic frequency sound generating devices offer a relatively new and largely untested or poorly tested method to keep mice out of homes. Most past tests to date have reported ultrasound to be either ineffective or only partially effective in repelling mammals, including bats, (Hurley and Fenton 1980), and rodents (Bomford and O'Brien 1990, Munro and Meehan 1987) though Whitford (2011) reported 98.46 % reduction in bat droppings following use of Transonic Pro sound generating devices, such as those use in this study. The current study was designed to evaluate the efficacy of several forms of these devices in reducing mouse presence and evidence in homes with as little human time and effort input as possible. Additionally, since mice can wreak havoc on ripening melons and tomatoes, especially in drought years when these represent a significant water source for thirsty mice, tests were conducted on efficacy of ultrasound units designed for outdoor use as a means of reducing crop damage in a large vegetable garden.

## METHODS

Rather than use an unnatural lab based testing using plexiglass enclosures and confined mouse populations, I chose to use free natural populations of mice as in test designs previously used to test efficacy of sound devices against the Norway rat *Rattus norvegicus* (Ashton, 1999). I feel such real world tests on free populations produce far more valid results than artificial enclosure studies, based on my 35 years field experience doing research in natural settings as a PhD in ethology. Equipment efficacy is best tested in the natural environment for any species, for normal responses to novel stimuli are far more likely to be witnessed in such settings than in unfamiliar surroundings. This same principle of testing in natural settings has also been strongly advocated for in print (Beck and Stein 1979) expressly as a means of obtaining the most valid results of new equipment to be tested in repelling vertebrate pests.

The necessary first step to this type of research is to design tests that help to establish that the species studied can perceive and does show response to the auditory signals generated by the equipment to be tested. Lacking references for details of specific frequency ranges perceived by, and auditory acuity of, White-footed Deer Mice, *Peromyscus leucopus*, I relied on an indirect assessment of sound detection. I hypothesized that repeated observation of alteration of behavior or avoidance of normally used areas by individuals of P. leucopus when exposed to sounds produced by the TRANSONIC PRO and YARDGARD sound generating units (Bird-X Inc., Chicago, IL) would constitute the needed evidence that they perceived and responded with avoidance to such sounds. I set my study design to determine whether the sounds generated by these devices do or do not alter behavior/presence of mice in a measureable, repeatable fashion and whether they demonstrated efficacy in repelling mice from the home and or garden environment.

### Research site

The primary research site used for these tests of the ultrasound equipment efficacy in reducing mouse presence and droppings evidence was an old farm house in Marquette County, Shields Township section 6, in Central Wisconsin. It was constructed in stages with central rooms dating to 1870 and addition of 2

extra bedrooms and a second floor with 4 bedrooms between 1920 and 1925. Final additions of indoor bathroom and a back hall that provided access to a new stairwell leading to the fieldstone-walled basement were made in 1964. Its construction and age make it highly porous to the invasion of mice. It has been the weekend recreational residence of the author and his family for 53 years. As an obsessive compulsive biologist, I have kept marginally complete 25 year records of small mammals caught or killed there. Of more than 500 mice caught in the house in that time in snap traps, live traps, glue pads, and drowned in antifreeze in winter toilets or water buckets in the basement, only two have been the common gray "House Mouse" *Mus musculus*, from Europe. All remaining mice were the native White-footed Deer Mouse. Among the highest recorded two day (generally weekend time frame) totals were 7 deer mice trapped in 48 hours Dec 26 and 27, 1996 (Whitford 1997). Reproduction in this species continues as long as the mice are warm and Central Wisconsin litters were reported to average 4.77 per pregnancy (Long, 1973). Mouse numbers vary seasonally and year to year, based on food supply, habitat and weather. My records indicate they generally begin entering the house in late August or early September, and peak in November or December, as they search out winter homes. They continue to move into the house in lesser numbers until April, when catch rates declined. Suffice it to say that mouse droppings and sightings (and continual trapping) were a normal part of life in this house since I first came there in 1955.

**Study design**

Ultrasound units tested were provided by Bird-X, Inc. Chicago Il., 60607. They included 1 TRANSONIC PRO, (Frequency 3 – 40 KHz at a sound pressure of 96 db @ .5 m), which was used exclusively in the house, for it is not water resistant. This unit was set to the "medium" volume and "spider" setting on the options for sound output for the test. I did not use the "mice" sound setting since prior spider tests had indicated mice responded more strongly to the spider setting than to the predesignated 'mice" setting of the units' controls.

Two complete cycles of trapping and recording mice caught ran from 2 August-5 December and were carried out within the back hall/stair well area of the farm house in the fall of 2009 and in the fall of 2010. In 2009 the Transonic pro sound unit was turned on and left on for the full time. In 2010, it was present, but unplugged for the entire test cycle. This provided 2 sets of absolutely comparable mouse trapping data for the exact same location and house during the period when highest entry and past trapping was recorded in prior years. A repeat test with the sound unit turned on was made for a full year 25 November 2012 to 25 November 2013. All test periods 2009, 2010, and 2012-2013 the sound generating unit was placed in the 1 X 3 meter back hall at the point where the 1.2 cm gap beneath the inner door to the main house provided what I believed to be the principle entrance to the rest of the house for mice. The other end of the hall ended at an exterior storm door that prevented mouse entry from that point and intersected the flight of concrete stairs leading up from the basement. Mice were presumed to regularly enter the house along old decaying wooden foundations laid atop a short stone base beneath the main rooms of the house. From there, they moved into the main house by entering the basement and then coming up the basement stairs and in through the back hall. Placement of the sound unit in the hall forced mice to pass within less than 1 meter of the sound generated to gain entry to the main house, thus exposing them to the full 96 dB sound at .5 m.

At all times in both 2009 and 2010 and in 2012-2013 tests, 6 Victor@ brand mouse snap traps were present on the top three steps of the basement stairs. Bait was changed once every 30 days, or when fully consumed on any trap, to provide equal freshness of peanut butter used on all traps for studies with the sound unit on and with it off. As usual for the house, garbage and recycling bags were placed between stove and counter end on the kitchen floor and left there until full for disposal in all years. Additionally, a 3.8 liter, uncovered compost bucket was continually present on the kitchen counter in all years. Again, it was emptied only when near full or malodorous. Mouse traps were checked and emptied on Friday evenings when I arrived at the farm house and reset/rebaited as needed. Dropping counts were also made upon entry for counters, stove and floors, All floors, counters, stairs and basement areas were thoroughly vacuumed before the research was begun each year to remove all visible mouse evidence.

Secondary outdoors tests on efficacy of eliminating mouse damage to crops were conducted using a YARDGARD sonic/ultrasonic unit, (Bird-X Inc. of Chicago) freq. 15 kHz-25 kHz, 90 dB at 1 m maximum in a 36 m X 25 m fenced garden area. This test was begun 9/1/2009 following 21 days of finding 6 - 8 nearly ripe tomatoes heavily gnawed each morning (all those near ripe enough to pick in a year of late tomato ripening in central Wisconsin). Extremely thin width of incisor marks left on tomatoes left no doubt that either mice, voles or shrews were responsible, but none of the guilty culprits were trapped there in 20 days/nights of trap effort before adding the YARDGARD. Past small mammal trapping (associated with my 1973 Mammalogy course at UW-Stevens Point) of sites within 200 m of the test site had yielded specimens of the following species of small mammals in addition to frequent sightings of P. leucopis: short-tailed shrew, *Blarina brevicauda*, pygmy shrew, *Sorex hoyei*, long tailed shrews of the species *Sorex cinereus*, voles of both *Microtus pennsylvanicus* and *M. ochrogaster* species, and red-back voles, *Clethrionomys gapperi*, and the woodland jumping mouse, *Napaeozapus insignis*. Ultrasound testing as protection of tomatoes began 1 September 2009, the day the YARDGARD unit was delivered, and continued until hard frost destroyed the tomatoes September 28th.

Lack of evidence of droppings (house) and feeding damage (garden) and/or absence of mice in traps was considered to be valid indirect evidence of sensitivity by the mice to the sound frequency broadcast by the units being tested and to represent documentable reproducible changes in behavior in response to those sounds being broadcast. Thus, any or all of these were considered to be indicative of efficacy of the units in reducing mouse presence and/or damage.

**RESULTS**

**Fig. 1: Droppings**

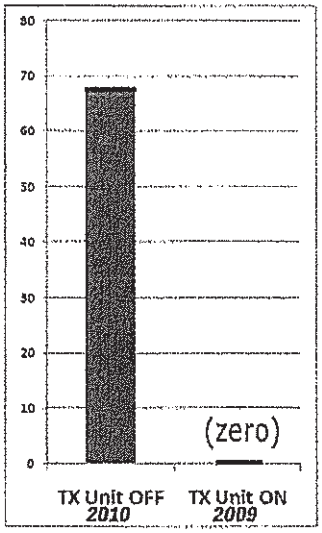


**Fig. 2: Mice trapped**

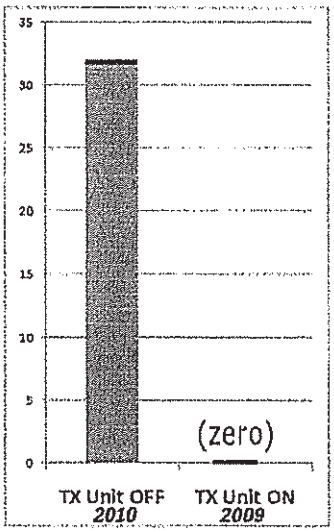


**Fig. 3: Tomatoes gnawed**

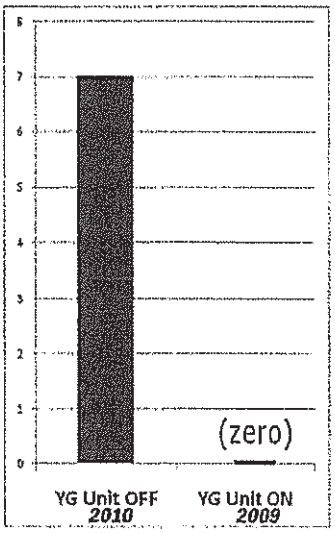


**Figure 1:** Comparison of Records of **Mouse Droppings** Observed on Kitchen Counters 8/5/09- 12/5/09 and 25 November 2012- 25 Nov. 2013 (with Transonic Pro unit ON), versus 8/5/10 -12/5/10 time period and same farm house with Transonic Pro unit OFF.

**Figure 2:** Comparison of Records of **Number of Mice trapped** 8/5/09- 12/5/09 and 25 November 2012- 25 Nov. 2013 (with Transonic Pro units ON), versus 8/5/10 -12/5/10 time period and same farm house with Transonic Pro units OFF.

**Figure 3:** Average **number of tomatoes damaged by mice** per night 8/11-9/1/2009 WITHOUT YARDGARD ultrasound unit versus 9/2-9/28/2009 WITH YARDGARD unit ON in tomato section of garden.

No mice were trapped on the basement steps or elsewhere in the house from August 2, 2009 - 5 December 2009, and only 6 were trapped for the full year long 2012-2013 test, the times when the Transonic Pro unit was producing its ultrasounds in the back hall. No droppings were observed/removed from kitchen counters, stove top or floor during that time in 2009 and only 3 were found for the year-long 2012/2013 tests. No damage was done to food stuffs in cupboards and cabinets for those time periods. Additionally, no signs of mice were found in the 24 square meter basement at the bottom of the stairs, and no mice were drowned in the drain bucket for the plumbing or in the toilet bowl of the bathroom just off the back hall. This compares to a minimum of 10 drowned mice recovered from the basement pump drain bucket and bathroom toilet bowl in all prior years at this house.

Even more telling as to efficacy of the unit, in contrast to the complete absence of mice trapped or seen and droppings observed in tests during 2009, or 6 mice in a year 2012.2013, 32 mice were caught on the basement stairs between 2 August and 5 December, 2010, when the sound unit was turned off. Even with this number removed, there were multiple sightings of mice in the kitchen, and regular signs of droppings in 2010. A total of 67 droppings were counted on the kitchen counter and many dozens more were swept up off the floor near the garbage storage area.

Normally a Chi Square test can not be done using zero as the expected value (per. comm. Dr. Andrea Karkowski, Statistician Capital University Psychology Department. Columbus OH) so a value of one was substituted at her suggestion for the zero mice caught in 2009 and also for the zero droppings observed in 2009 so the statistical tests could be done. Thus, the $X^2$ value for mice in 2010 is 961 ($p = .000$) and the $X^2$ value for the mouse droppings in 2010 is 4356 ($p = .000$). Chi square values for mice/month and droppings/month for 2012/13 test versus 2010 data were 11.343, $P = 0.0034$ and 26.855, $p = 0.000001$, respectively. This means the statistical probability that the difference between year 2009 and 2010 and between 2010 vs 2012-2013 test data resulted from chance is virtually zero. Since no other differences were present between these tests in the two years (even the weather was comparable) the only reasonable conclusion is that use of the Transonic Pro was the explanation for the difference in number of mice trapped. Ergo, there is no question that the mice perceive the sounds generated and respond to them by almost complete avoidance of the area. Thus, efficacy of the units in these tests was 100 % for 2009 and 93.75 % for 2012-2013 for the areas tested, and included the basement stairs and hallway, kitchen and basement, or roughly 440 sq feet (roughly 42 sq meters) on two levels.

As to garden mice (or, perhaps, voles or shrews) the first night the YARDGARD Unit was installed in the garden, 9/1/09, all damage to tomatoes and melons by gnawing small mammals ceased. There was no evidence of damage from that time until the test ended on 9/28. The area protected by the single sound unit was roughly 16 X 12 meters, 192+ sq meters. It may have effectively been larger, but no crops were present outside this area that evidenced attraction for the species doing the damage. Thus, it is unclear without further research what maximum area a single YARDGARD unit would effectively protect from this/these species. Similar to the Transonic Pro unit in the house, the YARDGARD sound unit in the garden was clearly perceptible to and caused aversion and avoidance on the part of the small mammals that had been feeding there and damaging crops. Efficacy was 100 % at reducing crop damage in the test area for the duration of the tests.

DISCUSSION

Contrary to prior reports of lack of demonstrated efficacy or only partial efficacy of ultrasound units to repel rodents (Bromford and O'Brien 1990, Munro and Meeham 1987), the results for the tests with the YARDGARD and Transonic Pro ultrasound units were unequivocal and strongly indicated audibility to the mice and a high level of efficacy at reducing mouse presence and damage in both garden and house situations. Placement of the unit in the house, where mice had to pass it to enter the kitchen and other

main areas, may have been fortuitous, in that it exposed the mice to the greatest sound pressure level for the frequency used. However, it also appeared, based on lack of visible evidence, to keep mice from using the entire basement area, so that placement of the unit may not have been the sole issue in its success.

In general, past research and claims for efficacy of ultrasound based deterrents has been inconsistent, with Bromford and O'Brien (1990) advocating "deer whistles" for reducing deer car accidents as "scientifically sound and humane." More recently, several studies have determined that some commercially available deer whistles don't produce the ultrasound frequencies claimed (Schildwachter et al. 1989, Scheifele et al. 2003) or produced no changes in behavioral responses of white-tailed deer (Schildwachter et al. 1989, Valitzski et al. 2009) or mule deer (Romin and Dalton 1992) exposed to moving vehicles traveling with mounted whistles. Such inconsistent and inconclusive results have left most people skeptical about the use of ultrasound as a useful deterrent to animal pest species.

In a somewhat similar manner, conclusions of past studies of ultrasound as lacking demonstration of efficacy (Bromford and O'Brien 1990) or evidencing only partial efficacy (Munro and Meeham 1987) for dispelling rodents are at odds with the very concrete results of strongly supported efficacy found in this real world study on white-footed deer mice.

There is little question that any prior research on the use of ultrasound to repel mice which concluded it to be "ineffectual or only partially effective" was incorrect in those conclusions based on the unambiguous results in this study. The most logical explanation for why prior studies might have failed to find ultrasound effective is that "ultrasound" as a name defines an extremely large range of sounds above normal human hearing frequency, from 21000 Hertz to well over 140000 Hertz. Thus, use of incorrect ranges of ultrasound frequencies to attempt to repel mice in past research would mean that the species studied might not be able to hear them, and thus could not respond to them. A second confounding variable in any such study is that very high frequency sounds have extremely short wave lengths and very little energy, and thus dissipate rapidly in air, and even more rapidly in dense vegetation and/or wooden enclosures, and insulation materials. As such, tests conducted to determine perception or response at distances beyond several meters might fail simply due to attenuation/absorption of much of the high frequency sound spectrum by the surrounding air and sound environment. One might mention that tests conducted in an unnatural setting might see little change in behavior of an animal that is already agitated by the strange environment it finds itself in and proximity of researchers, or conversely could rapidly habituate to the sound if it could not get out of hearing range of it, and no adverse effects occurred over time of exposure to the sound. Finally, though it is by no means an exhaustive list of possible reasons why ultrasound tests might give false negative outcomes, it is possible that several hundred generations of selective breeding of white lab mice could have inadvertently resulted in some degree of genetic hearing loss in the ultra sound frequency range, in part due to lack of selection pressure for such hearing acuity in a safe, caged environment. Any of the above alternatives would lead to ambiguous results or a false conclusion about the efficacy of ultrasound for preventing mice from use of given areas.

In the test of the YARDGARD in the tomato portion of a large garden, tests found the same

100 % efficacy, judged by the elimination of tomato damage, that was observed in the house. So, while Curtis et al. (1997) concluded from their research using the YARDGARD, that it was ineffectual at repelling hungry winter deer from apple bait piles, they unquestionably have been shown to provide a major reduction in crop damage by mice in kitchen gardens and may have application or organic farming situations. The research goal of Curtis, et al., was to determine whether ultrasound would serve to keep deer from damaging ornamental plants. They tested for this with simulated tests using apple feeding stations in winter, placed 10 m from the sound units. They were considered ineffectual at keeping deer away. This should have surprised no one, since there is no reason to expect deer to hear strongly in the ultrasound range. The large body size of deer means their vocal apparatus is very large and not suited for generating high frequency sounds, so they are unlikely to communicate in this sound range. Unlike dogs, coyotes, wolves, cats, and owls, which do hear at least some of these sounds and rely on them to locate rodent prey species that do communicate with ultrasounds, deer are herbivores and do not hunt prey that communicates in this sound range. Thus, there is little reason to expect there was selection for auditory perception of low frequency ultrasound ranges by deer. Finally, even if deer were able to discern this sound, placement of the sound units 10 m from the apples would reduce the decibel level to nearly inaudible, if not inaudible, ranges due to sound attenuation in the cold air, before the sound reached the apple pile.

Despite the fact that dogs are known to hear into the low end of the ultrasound range (think silent dog whistles), and show aversive responses to some ultrasound frequencies (Blackshaw et al. 1990) there was no evidence observed in this study that the sounds generated by either the Transonic Pro or the YARDGARD were audible or distressing to dogs. Both a 5 year old Golden Retriever and a 7 year old Black Lab were regular visitors to the house used for the tests and never showed signs of perception of, interest in, or avoidance of the sound generating unit when it was on.

CONCLUSIONS

It is clear that frequencies produced by both the Transonic Pro and the YARDGARD units tested in this study are audible to wild white-footed deer mice (and perhaps voles or shrews in the garden setting) and caused them to avoid proximity of such sounds. In both indoor settings and outdoors there was a major reduction in evidence of mice or other small mammals during the times the sound units were on. This contrasted strongly with the abundance of mice present in spite of continual trapping efforts and removal of 32 mice from the house when the sound unit was turned off. Tests demonstrated the efficacy of the tested units in precluding mice from using the areas where the sound units were on, and eliminated nearly all need to clean mouse droppings from kitchen counters or to bait, set, or empty mouse traps, or to worry about use of poisons in homes with pets or small children. With proper placement and numbers of sound units for the area to be protected, the units provide an extremely easy, inexpensive and humane means to keep mice out of the home, or garden. There was no sign that mice habituate to the sounds or that the units lose effectiveness with continued use. Whenever

possible, I would advocate putting the sound generating unit on the floor near any entry point into the kitchen or food service area of restaurants and homes for maximum efficacy in reducing/preventing rodent entry. I also recommend that one or two snap traps be kept set to remove the occasional mouse that fails to avoid the area based on the ultrasound alone. The two methods used together served very well to reduce mouse damage to virtually nonexistent levels and reduced time end effort on rebating and emptying traps.

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